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AN ANALYSIS OF MAXIMUM VERTICAL GUSTS RECORDED AT NASA'S 150-METER GROUND WINDS TOWER FACILITY AT KENNEDY SPACE CENTER, FLORIDA

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A statistical summary is presented of vertical wind speed data recorded at NASA's 150-Meter Ground Winds Tower Facility on Merritt Island, Kennedy Space Center, Florida. One year of continuous around-the-clock vertical wind speed measurements processed by the Automatic Data Acquisition System (ADAS) is classified as a function of tower level (10, 18, 60, and 150 meters) and period of reference [day, month, season: winter (October through March) and summer (April through September), and annual]. Intensity, frequency, time of occurrence, prevailing conditions, etc., of the daily maximum vertical gusts (i.e., updraft and downdraft) are determined. The results are compared with the vertical gusts associated with the daily maximum horizontal gust. The intent of this summarization of vertical wind speed data is to provide a general description of wind flow in the lower 150 meters of the atmosphere for the identification of hazards involved in wind shear encounters relative to ascent and descent of the Space Shuttle and conventional aircraft.

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AN ANALYSIS OF MAXIMUM VERTICAL GUSTS RECORDED AT NASA'S 150-METER GROUND WINDS TOWER FACILITY AT KENNEDY SPACE CENTER, FLORIDA

SUMMARY

This report presents a statistical summary of vertical wind speed data recorded at NASA's 150-Meter Ground Winds Tower Facility on Merritt Island, Kennedy Space Center, Florida. One year of continuous around-the-clock vertical wind speed measurements processed by the Automatic Data Acquisition System (ADAS) is classified as a function of tower level (10, 18, 60, and 150 meters) and period of reference [day, month, season: winter (October through March) and summer (April through September), and annual]. Intensity, frequency, time of occurrence, prevailing conditions, etc., of the daily maximum vertical gusts (i.e., updraft and downdraft) are determined. The results are compared with the vertical gusts associated with the daily maximum horizontal gust. The intent of this summarization of vertical wind speed data is to provide a general description of wind flow in the lower 150 meters of the atmosphere for the identification of hazards involved in wind shear encounters relative to ascent and descent of the Space Shuttle and conventional aircraft.

INTRODUCTION

In the past the common assumption was that vertical winds at the surface could be disregarded. Statements from publications during this decade cast doubt on this supposition. Horizontal gusts have more significant effect on landing an aircraft than vertical gusts, although both have noticeable effects separately and in combination [1]. Other investigators have come to the opposite conclusion [1]. A study for the Pittsburgh area of factors in V/STOL site selection showed that at 24 and 46 meters vertical gusts are not Gaussian, updrafts are 2 to 3 times more frequent than downdrafts, and updrafts are 20 to 60 percent

more intense than downdrafts [1]. The behavior of the wind in the last 30 meters of descent, in particular between 30 and 15 meters during which some aircraft travel approximately 300 meters in 4 to 5 seconds, is most important to a descending aircraft whether a manual or an automatic landing is being executed [2]. From the National Transportation Safety Board data for 1970-1974 of 31 accidents for which wind shear or turbulence appeared to be a contributing factor, four accidents were caused by sudden wind shift, 10 by downdraft-updraft, and 17 by unfavorable wind [3]. Of the 10 downdraft-updraft accidents, 5 were commercial aircraft and 5 were noncommercial, 8 were during landing and 2 during takeoff, 4 occurred in June, and 1 each occured in January, February, April, August, November, and December. This report provides detailed vertical wind speed data which may be useful in problem areas concerned with ground wind environment at the Kennedy Space Center or areas with similar terrain, conditions, etc.

DATA

The 150-Meter Ground Winds Tower Facility located on Merritt Island, Florida, approximately 4.83 km (3 miles) west of Launch Complex 39 and northeast of the Space Shuttle landing runway is the source of the wind data summarized (Figure 1). A detailed description of the facility is given by Kaufman and Keene [4]. Figure 2 shows the placement of the meteorological sensors on the tower. Note the Gill propeller vertical wind speed sensors at the 10-, 18-, 60-, and 150-meter levels. Table 1 lists the parameters measured at the facility, the beginning record date, and the measurement levels. The ADAS, operational since August 1971, samples at a rate of 10 samples/second, digitally records, and real-time processes the data from the sensors [5]. Six 10-minute computational sequences of means, extremes, standard deviations, etc., are performed each hour and listed by the system teleprinter. More than 50,000 samples of vertical wind speed maxima for each level were examined for this investigation, representing 97 percent of the possible data for one year (i.e., January 1973, February through October 1975, November 1974, and December 1972). Specifically, the daily maximal updraft and downdraft for each level were determined and grouped according to day, month, and season.

Some interesting statistics and comparisons from this study of daily maximum vertical gusts are presented in tabular form. The extremes, means, and standard deviations are given in Tables 2 through 9. Missing periods of

data (1 day in June, 2 days in January, 3 days in April and in May, and 14 days in April at the 150-meter level) were caused by lightning striking the tower, birds striking the instrumentation, etc. Tables 10 through 14 present percentage frequency distributions of intensity and time of occurrence of the daily maximum vertical gusts. Actual number of occurrences of 10-minute maximum vertical gusts equal to or greater than 5.0 ms^{-1} recorded during t' › year, of precipitation associated with the daily maximum vertical gusts, and of coincidence of daily maximum vertical gusts with maximum vertical gusts associated with the daily maximum horizontal gust are shown in Tables 15 through 17. Comparisons of these 1970' s data with a somewhat similar investigation of data recorded in 1969 and with data recorded during hurricane Agnes on June 19, 1972, are included in Tables 18 through 20.

DISCUSSION

The maximal value determined in this year of 1970' s data is an updraft of 9.4 ms^{-1} in March at the 18-meter level, but it should be noted that a 9.3 ms^{-1} downdraft was recorded at that level in April. In general, the extreme (≥ 4.0 ms^{-1}) updrafts were recorded at the 18-meter level during the winter and summer months, while the extreme (≥ 4.0 ms^{-1}) downdrafts were at the 60- and 150-meter levels during summer. Comparison of the intensity of the daily maximum updraft and downdraft revealed the following: at the 150-meter level updrafts exceed downdrafts 61 to 94 percent of the time for September through January and downdrafts exceed updrafts 65 to 97 percent of the time from February through August, at the 60-meter level downdrafts exceed updrafts 87 to 100 percent of the time with the exception of January, at the 18-meter level updrafts exceed downdrafts 87 to 100 percent of the time, at the 10-meter level downdrafts exceed updrafts 52 to 67 percent of the time from September through January and during April and June and updrafts exceed downdrafts 45 to 58 percent of the time during February, March, May, July, and August. At all levels and for all months the maximal daily updraft and downdraft are equal less than 10 percent of the time.

The coincidence of the daily maximum vertical gusts with the maximum vertical gusts recorded in the 10-minute period of occurrence of the daily maximum horizontal gust was 25 percent or less throughout the year at all levels.

Time of occurrence of the daily maximum vertical gusts at all levels was 1900 to 0700 EST approximately 10 percent of the time, 0700 to 1300 EST 55 percent, and 1300 to 1900 EST 35 percent. The actual number of recorded occurrences of precipitation with the daily maximum vertical gusts was only 80 at all levels for the year.

Although the maximal updraft and downdraft determined from the 1969 data were less than those for the 1970's data, the mean values during both seasons in 1969 were greater at three of the four levels.

Actual measurements of extremely high winds are rare during tornadoes because highest winds normally occur where usually there are no anemometers. During the sweep of hurricane Agnes across the Florida Panhandle in June 1972, however, tornadoes occurring along the leading edge were observed in the Cape Canaveral area. These tornadoes crossed Merritt Island and struck near Launch Complex 39B where trailers and other structures were damaged. Maximum vertical gusts recorded at the Ground Winds Tower Facility from 0300 through 0500 EST during these tornadoes on June 19, 1972 are presented in Table 20, together with the maxima of the 1969 and 1970's data for comparison.

A companion study will be available soon for this same period of data from NASA's 150-Meter Ground Winds Tower Facility (on stand-by status since November 1975) which should provide more information about means and extremes of daily horizontal wind speeds, gust factors, and other relevant parameters in the identification of hazards involved in wind shear encounters relative to ascent and descent of the Space Shuttle and con entional aircraft.

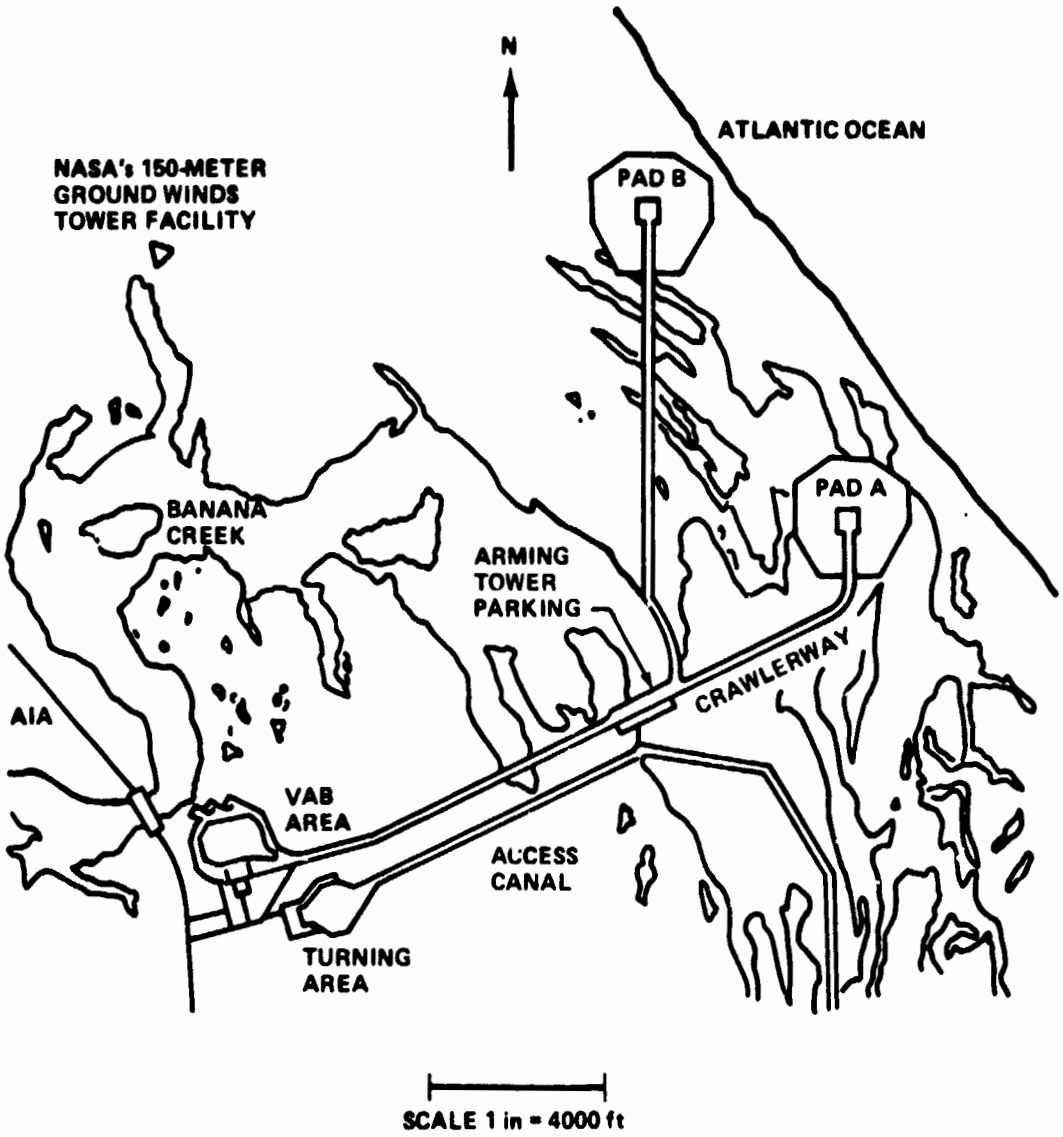

Figure 1. NASA's 150-Meter Ground Winds Tower Facility and Launch Complex 39, Kennedy Space Center, Florida.

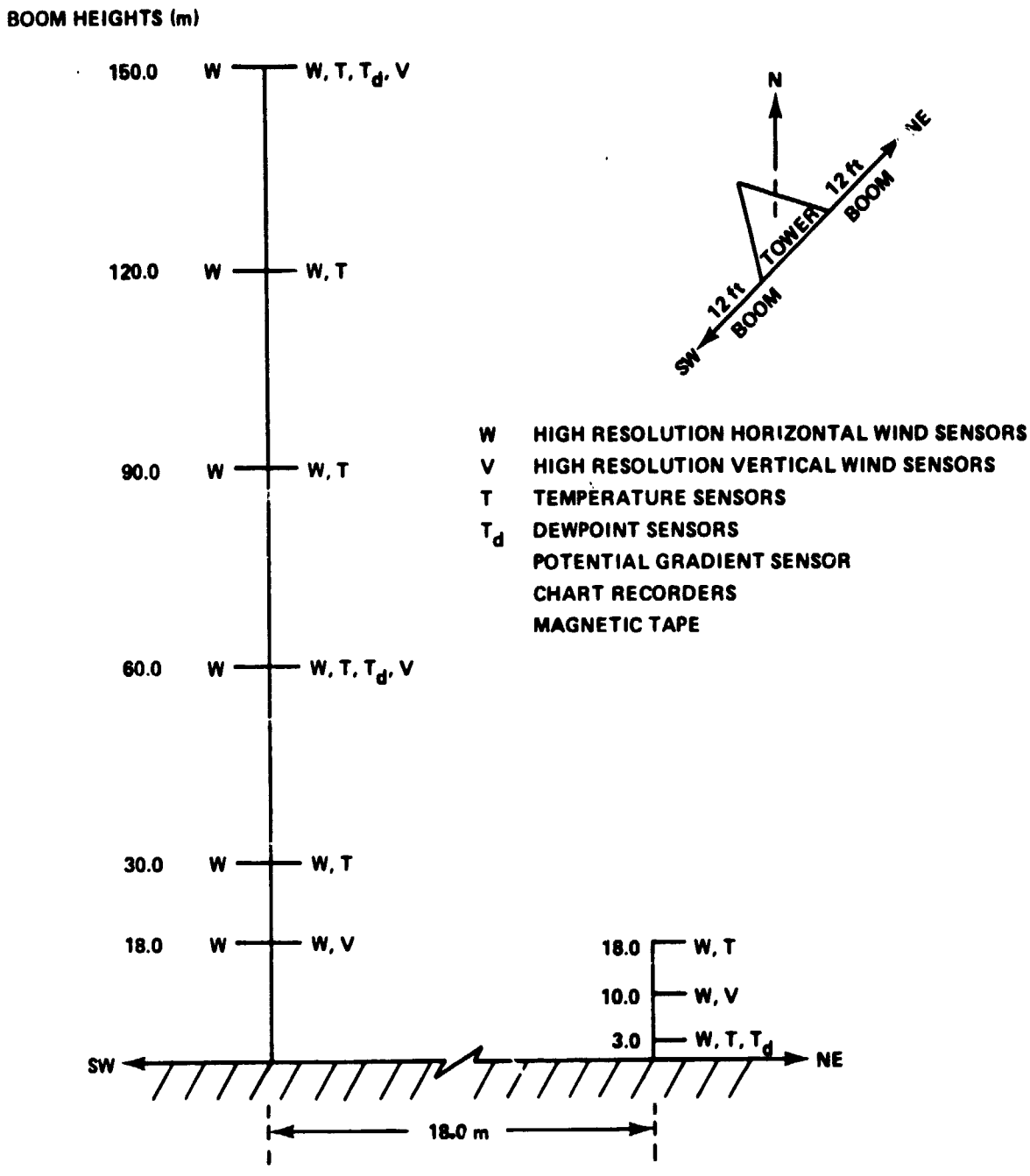

Figure 2. Placement of sensors on NASA's 150-Meter Ground Winds Tower Facility at Kennedy Space Center, Florida.

TABLE 1. PARAMETERS MEASURED AT NASA'S 150-METER GROUND WINDS TOWER FACILITY AT KENNEDY SPACE CENTER, FLORIDA

Parameter	Beginning Record	Measurement Levels (meters)
Wind Speed (ms^{-1})		
Horizontal	December 1, 1965	3, 18, 30, 60, 90, 120, 150
Horizontal	April 30, 1968	10
Vertical	February 26, 1969	10, 18, 60, 150
Wind Direction (degrees)		
Horizontal	December 1, 1965	3, 18, 30, 60, 90, 120, 150
Horizontal	April 30, 1968	10
Temperature (^{o}F)		
Ambient	December 1, 1965	3
Delta	December 1, 1965	18, 30, 6[illegible] 120, 150
Dew-point	February 16, 1968	3, 60, 150
Atmospheric Pressure (mb)	April 7, 1966	1.5
Relative Humidity (%)	March 7, 1966 April 20, 1966	1.5 120
Solar Radiation ($cal/cm^2 min$)	August 18, 1967	1.2
Precipitation (inches)	February 10, 1969	1.5
Electrical Disturbances (miles)	August 15, 1969	6

TABLE 2. DAILY MAXIMUM UPDRAFT (ms^{-1}) RECORDED AT 10-METER LEVEL

	Winter						Summer					
Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep
1	1.3	2.0	2.4		1.9	2.6	3.2	2.2	2.9	2.2	2.9	2.2
2	1.5	1.6	1.0		3.2	3.0	3.5	2.4	2.6	2.7	2.0	1.7
3	1.5	1.8	1.1	1.5	2.6	4.2	4.6	3.4	2.1	2.2	2.3	2.5
4	2.0	2.0	1.1	0.6	3.1	3.1	3.2	3.5	3.2	2.6	4.2	2.8
5	2.6	1.9	1.1	1.2	3.5	4.0	2.7	2.8	2.1	2.4	2.3	3.4
6	2.5	2.1	1.2	1.3	3.6	2.5	3.1	2.1	2.2	2.7	1.9	2.4
7	3.3	2.8	1.7	1.4	2.9	2.4	2.3	3.1	3.7	3.0	2.3	2.5
8	2.3	2.6	1.2	2.1	2.6	3.2	2.6	2.8	4.2	2.3	2.9	2.4
9	1.9	3.6	1.2	2.5	2.1	3.6	2.1	2.3	2.3	2.6	2.4	2.8
10	2.0	3.0	0.9	2.7	2.5	2.9	2.4	1.6	2.0	3.2	3.0	1.9
11	2.6	2.4	0.6	3.1	2.2	2.7	3.1	2.7	2.4	4.6	2.2	2.3
12	1.8	2.9	1.0	3.4	3.0	3.8		3.2	2.9	3.9	3.0	1.8
13	2.3	3.1	0.9	3.2	2.5	4.1		2.4	2.5	3.6	2.3	1.5
14	2.2	1.8	1.2	2.1	2.9	5.7		2.3	2.5	2.3	1.6	1.5
15	1.9	2.4	1.9	1.7	2.4	2.3	2.5	1.9	2.6	2.3	2.3	1.7
16	2.1	2.3	4.4	1.2	4.1	3.4	3.0		2.9	2.6	3.2	2.1
17	3.9	2.3	3.3	1.0	2.4	2.6	3.1		1.8	2.3	1.5	2.5
18	2.4	3.2	2.3	1.2	3.4	4.1	3.4		2.2	2.4	1.9	2.7
19	2.5	1.7	1.2	2.4	3.6	2.6	3.2	3.3	2.9	1.9	2.3	2.3
20	2.0	4.0	0.8	1.2	2.1	2.2	3.9	2.9	3.3	3.6	2.4	1.8
21	2.2	3.6	1.6	1.4	1.8	2.3	2.3	2.7	2.3	2.3	3.1	2.1
22	2.2	4.1	2.5	3.4	2.6	3.7	3.5	3.6		1.4	2.1	2.9
23	2.2	2.2	1.9	1.5	4.2	3.1	3.7	2.3	3.0	2.6	2.5	3.7
24	2.6	1.8	1.6	1.9	5.3	4.9	2.9	2.5	1.7	2.6	2.6	2.3
25	0.9	1.5	2.5	1.4	2.6	3.1	2.4	2.7	2.1	2.9	2.6	1.9
26	2.4	3.0	1.6	1.3	4.1	2.3	2.7	2.2	2.2	1.7	2.7	2.3
27	1.3	2.1	2.5	1.2	2.9	3.1	2.0	3.3	2.5	3.1	2.7	1.7
28	1.8	1.0	1.6	2.1	1.8	4.1	2.8	2.5	2.4	2.6	3.2	2.3
29	1.2	0.7	1.1	4.2		2.9	2.6	2.1	1.9	1.9	2.6	1.5
30	2.1	1.3	1.4	1.7		3.8	4.0	3.3	2.1	2.3	2.8	2.2
31	2.4		1.0	0.7		2.6		3.4		2.9	3.4	
Mean	2.13	2.36	1.61	1.88	2.93	3.25	2.99	2.70	2.53	2.63	2.56	2.26
Std Dev	0.60	0.84	0.82	0.90	0.83	0.83	0.62	0.54	0.57	0.66	0.56	0.53
Maximum Monthly	3.9	4.1	4.4	4.2	5.3	5.7	4.6	3.6	4.2	4.6	4.2	3.7
Seasonal			5.7						4.6			
Annual						5.7						

TABLE 3. DAILY MAXIMUM DOWNDRAFT (ms^{-1}) RECORDED AT 10-METER LEVEL

	Winter						Summer					
Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep
1	2.0	2.3	2.0		2.0	2.7	3.4	2.9	3.5	3.0	2.6	2.4
2	2.5	2.5	1.1		2.1	5.3	2.8	3.0	3.6	2.9	1.9	2.1
3	1.9	2.4	1.0	1.9	3.2	3.5	4.6	3.1	2.9	3.0	2.3	1.7
4	2.6	2.0	1.0	1.5	3.0	3.3	3.5	4.0	2.8	2.5	2.6	2.5
5	2.4	2.3	1.6	1.4	3.1	3.7	2.8	2.5	2.4	2.4	3.3	2.1
6	2.5	1.8	1.9	1.7	4.2	3.3	3.0	1.9	4.0	3.0	2.3	1.9
7	3.0	2.9	1.2	1.3	2.9	2.4	2.6	2.4	5.0	2.5	3.7	2.5
8	2.1	3.0	1.5	2.5	2.3	5.0	3.2	2.7	3.6	2.4	2.6	2.7
9	1.7	3.0	2.1	2.2	2.4	4.2	2.5	2.5	2.0	2.3	3.4	3.0
10	2.3	3.3	1.1	2.1	1.8	2.6	2.5	2.3	2.4	2.4	2.4	2.3
11	2.1	2.2	1.6	1.8	2.1	2.0	2.9	2.7	3.6	3.0	3.1	2.2
12	2.2	2.6	2.2	2.6	3.1	3.4		2.5	2.6	3.4	2.8	2.4
13	2.4	3.1	1.5	2.5	3.4	3.6		2.7	4.5	2.8	3.1	1.8
14	2.6	2.1	1.7	2.2	2.6	3.9		2.4	2.3	2.3	2.0	2.2
15	2.8	2.8	2.4	2.0	3.4	2.6	3.2	2.4	2.8	2.8	2.2	1.8
16	2.0	2.0	2.4	1.3	3.1	2.5	3.3		3.4	2.4	1.8	2.3
17	3.3	2.7	2.5	1.7	2.5	2.5	2.1		2.3	2.0	1.8	2.9
18	2.6	2.7	2.2	1.6	2.7	3.5	3.6		3.6	2.3	2.0	2.5
19	2.5	2.0	1.4	2.2	3.0	3.2	3.5	2.4	2.1	2.3	2.3	3.0
20	3.3	3.6	1.3	1.5	2.3	1.9	3.0	2.6	2.0	3.0	3.0	2.1
21	2.4	3.1	2.6	2.1	2.7	2.2	2.7	2.8	3.0	2.0	2.3	2.3
22	2.6	4.8	2.8	3.1	2.3	3.8	3.1	3.0		2.0	3.0	2.4
23	3.8	2.7	1.8	1.4	4.1	2.3	3.7	2.3	3.3	2.2	2.4	4.6
24	3.3	1.7	1.7	1.7	5.1	3.3	2.7	2.3	2.3	1.8	3.0	3.1
25	1.6	2.7	2.2	1.4	3.6	3.6	2.5	2.4	2.3	1.8	2.9	2.2
26	1.6	4.3	1.7	2.4	2.2	3.3	2.4	2.1	2.0	2.2	2.7	2.5
27	1.3	2.7	2.0	2.1	2.3	2.7	2.4	2.6	2.1	3.2	2.3	2.0
28	2.5	1.3	1.4	2.7	1.8	3.4	3.8	2.5	2.4	2.3	2.5	2.1
29	1.7	1.3	1.4	3.1		2.6	3.0	2.4	2.7	2.0	2.7	2.7
30	2.0	1.1	2.1	1.5		3.5	3.1	3.1	2.5	1.8	2.4	1.9
31	2.8		1.8	1.1		3.7		3.0		3.2	2.9	
Mean	2.40	2.57	1.78	1.95	2.83	3.21	3.03	2.63	2.90	2.49	2.59	2.41
Std Dev	0.57	0.81	0.49	0.54	0.77	0.79	0.54	0.40	0.78	0.46	0.48	0.55
Maximum Monthly	3.8	4.8	2.8	3.1	5.1	5.3	4.6	4.0	5.0	3.4	3.7	4.6
Seasonal			5.3							5.0		
Annual						5.3						

TABLE 4. DAILY MAXIMUM UPDRAFT (ms^{-1}) RECORDED AT 18-METER LEVEL

	Winter						Summer					
Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep
1	4.7	5.8	3.8		2.9	5.2	5.0	4.8	4.9	4.5	4.7	3.4
2	4.8	4.0	3.0		3.7	6.9	4.1	4.3	4.2	5.3	4.0	5.1
3	3.8	4.1	2.7	3.1	3.8	7.1	7.9	5.8	3.3	4.2	4.2	5.1
4	4.1	3.7	2.4	8.3	4.1	4.7	7.2	6.3	4.3	4.8	5.1	5.1
5	5.1	3.8	3.0	2.2	5.9	6.4	5.8	4.9	4.1	5.0	5.9	5.9
6	4.1	3.5	3.1	2.5	8.3	4.6	4.9	4.8	4.3	5.2	4.9	5.0
7	5.4	4.8	3.0	2.6	5.6	4.8	6.1	5.9	5.6	4.2	4.1	4.9
8	4.9	3.1	3.6	4.2	6.3	6.0	4.9	4.9	4.9	6.1	5.1	5.4
9	3.7	4.3	3.2	4.1	4.5	5.2	3.8	4.9	5.4	5.5	5.2	4.2
10	5.3	4.9	3.1	4.2	3.4	5.6	3.9	4.5	4.3	4.4	5.2	4.9
11	4.4	3.7	2.9	3.9	3.8	4.3	6.4	4.6	4.6	6.3	4.0	4.2
12	4.1	4.2	3.2	4.4	5.2	5.8		5.2	6.1	4.7	3.0	4.7
13	4.8	4.9	2.9	5.2	4.2	6.9		5.2	4.3	4.5	5.4	3.5
14	5.0	3.9	3.5	4.3	4.5	9.3		3.9	3.9	4.5	3.8	4.2
15	5.0	4.2	4.6	3.3	4.5	5.2	5.7	3.5	4.0	4.2	4.6	4.6
16	4.3	5.0	6.1	2.7	6.1	4.9	5.5		4.2	4.0	4.7	3.2
17	5.9	4.9	5.1	2.4	4.7	3.7	6.5		3.7	4.7	4.3	5.9
18	3.8	3.9	3.6	2.9	5.1	4.8	6.1		4.0	3.3	4.4	4.4
19	3.9	3.4	2.8	4.3	5.3	4.1	5.8	3.9	4.5	4.3	3.9	4.0
20	4.7	5.9	2.8	2.9	3.4	4.7	6.6	4.6	5.4	5.7	4.2	5.9
21	4.4	5.1	3.8	3.5	4.0	5.1	4.3	4.0	5.3	4.0	5.4	4.7
22	4.7	4.4	6.0	5.6	4.2	4.6	5.9	4.8		4.9	4.6	5.4
23	4.3	4.0	3.8	2.9	7.5	4.3	8.1	5.3	5.6	4.2	4.7	6.0
24	5.2	4.9	3.1	2.7	9.3	9.4	5.0	5.3	3.7	4.3	4.0	3.9
25	3.5	3.4	4.2	2.4	5.4	5.6	4.7	4.7	3.6	4.0	4.6	4.0
26	4.2	5.5	4.1	3.7	5.6	5.4	5.1	4.0	4.5	4.1	5.2	5.0
27	3.8	3.9	3.7	2.8	7.2	4.9	4.4	4 9	5.2	4.6	4.7	4.1
28	4.6	2.4	3.2	5.1	4.3	7.3	4.4	4.8	4.9	4.0	4.6	3.8
29	4.1	4.5	2.8	6.1		5.6	4.6	4.9	4.5	5.7	4.2	3.9
30	4.8	2.6	3.5	4.2		6.1	8.6	5.6	4.5	4.7	5.1	5.5
31	5.3		3.2	2.6		7.1		5.1		5.4	6.2	
Mean	4.54	4.22	3.54	3.76	5.10	5.66	5.60	4.84	4 54	4.69	4.65	4.66
Std Dev	0.60	0.85	0.89	1.36	1.53	1.36	1.29	0.64	0.68	0.69	0.66	0.79
Maximum												
Monthly	5.9	5.9	6.1	8.3	9.3	9.4	8.6	6.3	6.1	6.3	6.2	6.0
Seasonal				9.4						8.6		
Annual						9.4						

TABLE 5. DAILY MAXIMUM DOWNDRAFT (ms^{-1}) RECORDED AT 18-METER LEVEL

	Winter						Summer					
Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep
1	2.1	1.8	2.8		1.9	2.0	1.9	2.2	3.0	2.2	3.0	1.8
2	3.3	2.2	1.7		1.2	6.3	2.3	2.5	3.4	2.8	2.4	2.2
3	1.7	1.8	1.3	1.5	2.8	3.2	5.7	3.0	2.0	2.3	2.1	1.7
4	2.1	2.7	1.3	1.1	2.2	2.5	3.8	5.2	2.0	2.2	2.2	2.3
5	2.7	2.3	2.3	1.2	2.2	4.7	2.9	2.0	2.5	2.6	4.6	2.4
6	2.0	1.0	1.4	1.4	5.3	2.9	3.5	1.6	3.0	3.2	2.7	2.6
7	2.7	3.2	2.3	1.2	2.0	2.8	1.8	1.9	5.3	2.6	2.5	2.5
8	1.7	1.9	1.8	2.1	2.3	3.1	2.4	2.2	4.1	2.5	2.5	2.6
9	1.9	3.1	1.8	2.4	2.3	4.7	3.0	2.4	3.0	4.8	2.5	3.4
10	2.4	4.1	1.2	3.3	1.7	2.7	3.3	4.2	1.8	2.8	3.0	2.0
11	2.2	2.7	1.5	3.8	1.8	2.2	3.1	2.4	1.8	2.6	1.7	2.3
12	2.5	2.7	1.9	4.0	2.9	3.1		2.4	1.9	2.4	2.4	2.7
13	2.1	3.4	1.6	4.0	3.1	3.6		3.5	3.2	3.3	2.4	3.2
14	2.6	1.4	2.1	2.8	2.6	3.9		1.8	2.2	1.6	2.0	1.8
15	2.4	4.2	2.6	2.3	4.7	3.1	3.5	1.1	2.1	2.9	2.0	1.2
16	2.7	1.8	5.1	2.0	3.4	2.5	4.2		4.0	2.1	2.7	2.5
17	4.2	2.4	4.3	2.9	2.6	2.7	9.3		1.5	1.7	1.4	3.6
18	2.0	1.9	3.1	2.4	2.0	2.3	3.5		2.0	2.3	1.6	2.5
19	1.8	1.7	1.7	2.3	3.0	2.0	4.7	2.4	1.9	2.7	2.6	1.9
20	2.8	4.2	1.5	1.4	2.0	2.1	3.7	2.4	2.5	3.1	2.4	2.1
21	2.7	5.5	2.5	2.2	2.2	1.9	3.0	3.0	2.5	1.1	2.6	1.8
22	2.6	2.3	3.3	3.5	2.4	2.9	3.8	2.1		1.7	3.0	3.2
23	5.1	2.0	2.8	1.3	4.7	2.2	4.7	3.7	2.7	1.8	4.3	5.3
24	4.6	1.4	2.1	1.8	4.9	3.9	3.0	1.9	1.7	2.5	2.7	3.6
25	2.6	3.4	3.0	1.4	2.6	3.3	2.3	2.3	2.2	1.4	2.5	2.8
26	1.7	4.6	2.6	2.5	1.9	3.0	2.7	2.7	1.6	1.5	2.9	2.7
27	2.1	2.3	3.0	2.7	3.9	3.0	2.7	2.2	2.0	4.3	2.1	2.5
28	3.0	1.0	1.6	2.9	2.1	3.9	2.6	1.8	2.5	1.6	4.5	2.4
29	3.6	1.2	1.7	4.3		2.7	4.0	2.0	3.0	2.0	2.7	2.8
30	4.1	1.7	2.0	3.6		3.0	3.4	3.0	2.1	2.6	2.2	2.6
31	4.4		1.6	1.4		4.1		3.0		2.9	2.1	
Mean	2.72	2.53	2.24	2.40	2.74	3.11	3.51	2.53	2.53	2.45	2.59	2.57
Std Dev	0.91	1.13	0.89	0.97	1.06	0.95	1.46	0.84	0.86	0.79	0.74	0.76
Maximum Monthly	5.1	5.5	5.1	4.3	5.3	6.3	9.3	5 2	5.3	4.8	4.6	5.3
Seasonal				6.3						9.3		
Annual							9.3					

TABLE 6. DAILY MAXIMUM UPDRAFT (ms^{-1}) RECORDED AT 60-METER LEVEL

	Winter						Summer					
Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep
1	2.2	2.0	2.8		2.9	2.3	3.5	3.6	1.9	2.4	2.5	1.5
2	4.7	2.4	2.1		1.8	3.6	3.0	2.6	1.9	2.0	2.2	1.6
3	1.6		1.3	1.9	2.2	2.7	3.2	1.7	1.9	2.9	3.0	1.5
4	2.1	2.2	1.7	1.6	2.3	3.2	2.7	3.1	2.1	2.4	2.3	2.3
5	2.2	1.4	1.9	1.	2.4	2.3	3.3	2.7	2.1	2.8	3.5	2.1
6	2.7	2.5	1.8	1.8	3.3	2.2	2.8	2.1	4.0	2.5	2.6	1.7
7	2.1	2.2	2.1	1.4	2.7	3.3	2.6	2.5	3.2	2.9	2.4	2.7
8	1.6	1.9	2.3	2.9	2.0	2.2	2.6	3.2	2.9	2.7	2.9	2.0
9	1.4	2.3	1.9	3.4	2.3	3.3	2.5	2.8	1.7	5.5	2.4	2.9
10	1.7	2.2	1.6	2.4	1.6	2.5	3.1	4.0	1.7	3.2	2.1	2.6
11	1.6	2.6	1.7	2.5	1.8	2.9	4.2	2.3	2.3	3.5	4.2	2.3
12	1.5	2.1	3.2	3.3	1.8	4.1		3.6	2.2	2.3	1.5	2.1
13	1.7	2.6	1.9	2.8	1.8	2.9		2.6	3.1	2.1	2.3	2.2
14	1.8	1.7	2.1	2.2	2.6	3.4		1.9	2.2	2.5	2.0	2.0
15	1.9	2.3	2.4	2.4	2.3	3.2	3.1	0.9	2.9	2.6	1.7	4.0
16	2.9	1.9	4.9	1.5	2.6	4.6	2.9		3.5	2.5	1.8	2.1
17	3.0	1.9	2.6	2.2	2.3	2.1	2.5		2.8	2.0	1.7	2.5
18	1.8	1.6	3.7	2.1	2.1	2.6	3.8		2.1	1.7	1.9	1.8
19	2.1	2.5	2.1	1.9	2.9	2.1	2.5	1.7	2.7	2.6	2.0	1.8
20	1.9	3.0	1.8	2.0	1.6	2.5	3.0	2.3	2.7	2.3	1.6	1.8
21	1.8	2.9	3.1	1.8	2.1	3.1	2.5	2.5	3.6	1.6	2.2	1.6
22	2.0	2.2	4.2	2.7	2.8	2.6	2.6	2.5		2.0	2.5	1.8
23	1.6	2.2	2.4	1.1	3.0	1.8	2.9	5.1	2.3	2.2	4.4	3.8
24	2.7	2.7	2.0	1.6	4.6	2.9	3.0	2.3	2.3	2.3	2.2	3.4
25	2.3	2.8	2.5	1.2	2.5	2.9	2.8	2.9	2.6	2.2	2.1	2.2
26	2.0	3.1	1.9	2.9	2.9	2.2	2.9	2.4	3.4	2.6	2.2	1.7
27	1.8	1.7	2.4	1.5	3.4	2.9	2.9	2.6	3.0	3.1	2.6	1.8
28	1.4	1.7	1.9	1.7	2.2	2.9	3.2	1.7	3.3	2.0	2.1	1.8
29	1.4	2.2	3.4	3.6		2.1	1.9	2.6	2.1	2.4	1.8	1.5
30	2.2	1.6	2.5	1.8		3.7	3.2	2.4	2.2	2.1	2.2	1.4
31	2.3		1.5	2.0		2.7		2.4		2.8	2.1	
Mean	2.06	2.22	2.38	2.12	2.46	2.83	2.93	2.61	2.58	2.54	2.35	2.15
Std Dev	0.64	0.44	0.92	0.67	0.64	0.63	0.46	0.80	0.62	0.69	0.67	0.66
Maximum Monthly	4.7	3.1	4.9	3.6	4.6	4.6	4.2	5.1	4.0	5.5	4.4	4.0
Seasonal				4.9						5.5		
Annual						5.5						

TABLE 7. DAILY MAXIMUM DOWNDRAFT (ms^{-1}) RECORDED AT 60-METER LEVEL

	Winter						Summer					
Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep
1	4.1	4.3	3.4		3.7	4.4	4.7	4.3	3.2	4.0	4.4	3.2
2	4.1	4.3	2.8		3.3	7.7	4.1	4.9	4.3	4.7	4.8	3.1
3	2.5		2.0	3.0	4.6	5.5	6.0	4.2	3.3	4.7	3.4	4.0
4	3.6	3.9	2.8	2.4	4.8	5.6	5.7	5.0	5.0	5.7	4.1	4.0
5	3.9	2.6	2.7	2.0	3.8	5.7	6.0	3.8	4.2	4.0	4.2	4.1
6	3.3	3.9	2.7	2.5	8.0	4.4	4.6	4.4	3.3	5.1	3.3	3.9
7	4.3	4.3	2.4	2.4	3.9	4.2	4.3	4.5	6.7	3.9	4.3	3.9
8	3.4	3.7	2.9	2.6	4.6	4.5	4.0	4.1	5.0	5.1	4.1	4.3
9	4.1	3.4	2.7	3.0	3.9	4.6	4.0	4.5	2.5	4.3	4.7	4.2
10	3.8	4.2	2.8	3.6	2.3	4.8	4.9	4.4	3.7	4.8	4.3	3.7
11	3.6	4.1	2.7	3.4	3.6	3.8	4.6	5.6	4.5	5.1	4.0	3.7
12	3.4	4.2	2.7	3.7	3.7	5.0		4.5	4.5	5.1	3.2	3.3
13	3.9	4.8	2.1	3.7	4.5	5.1		3.9	5.3	4.4	4.2	3.2
14	3.5	4.7	3.0	3.4	3.9	4.8		4.2	4.9	5.7	3.2	3.5
15	3.5	5.1	3.0	3.8	3.1	4.9	5.0	1.8	5.1	4.4	3.7	3.6
16	3.3	3.7	4.3	2.3	4.1	3.9	5.2		7.7	4.5	3.5	2.7
17	3.7	4.0	3.2	3.0	4.0	3.7	4.4		3.0	4.6	3.3	5.3
18	3.8	4.2	4.2	2.6	3.3	3.9	6.1		3.6	3.8	3.2	3.3
19	3.2	3.9	2.8	3.1	3.8	3.0	4.9	5.0	4.7	4.7	3.3	2.8
20	5.3	5.6	2.5	4.0	3.1	5.0	5.7	6.2	4.7	3.5	3.4	4.2
21	3.5	5.0	3.3	2.3	3.3	4.3	4.5	5.2	4.6	2.6	4.4	3.9
22	3.7	4.0	4.2	3.4	4.9	5.5	4.3	5.3		3.8	4.4	3.6
23	3.4	3.7	5.1	1.7	5.0	3.4	6.3	3.8	4.7	3.9	4.1	4.2
24	4.6	3.5	3.9	2.5	7.4	4.2	5.9	4.0	4.4	4.2	4.3	3.4
25	2.8	4.2	4.1	1.9	4.6	4.3	5.0	4.3	4.3	4.3	4.2	3.3
26	3.2	5.4	3.8	2.8	4.8	5.8	5.3	4.8	4.1	4.1	4.8	4.2
27	3.2	3.0	3.9	2.9	8.6	4.3	5.7	4.5	3.9	4.9	4.8	2.3
28	3.3	2.7	3.4	4.0	3.6	5.0	4.3	3.5	5.5	4.5	4.4	4.5
29	3.0	2.8	2.8	4.9		4.1	4.7	4.4	5.7	3.6	4.0	2.8
30	4.2	2.5	3.3	3.3		4.2	8.4	5.0	4.4	3.8	3.9	3.8
31	4.4		2.7	2.8		4.7		4.0		4.4	3.6	
Mean	3.70	3.99	3.17	3.00	4.36	4.65	5.13	4.43	4.51	4.39	3.98	3.67
Std Dev	0.52	0.79	0.71	0.72	1.44	0.88	0.96	0.79	1.07	0.65	0.53	0.62
Maximum Monthly	5.3	5.6	5.1	4.9	8.6	7.7	8.4	6.2	7.7	5.7	4.8	5.3
Seasonal			8.6						8.4			
Annual						8.6						

TABLE 8. DAILY MAXIMUM UPDRAFT (ms^{-1}) RECORDED AT 150-METER LEVEL

	Winter						Summer					
Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep
1	4.1	2.9	3.8		1.3	1.6		2.7	1.7	2.8	1.3	3.5
2	4.0	2.4	3.1		1.5	1.4		2.1	3.3	1.9	2.3	3.3
3	3.4	3.7	2.0	3.8	1.0	1.2		1.5	2.1	3.3	2.7	5.9
4	3.9	2.9	2.2	6.0	1.2	1.7		4.9	2.0	3.2	2.5	3.9
5	4.7	2.6	3.3	3.1	2.3	1.1		2.6	2.2	1.9	4.9	5.4
6	4.5	2.7	3.2	4.7	2.6	0.6		2.4	3.7	1.8	3.6	5.2
7	4.9	3.2	2.8	3.2	0.8	1.1		1.5	6.1	1.3	2.2	4.7
8	3.5	2.3	3.6	4.2	1.2	1.2		3.6	2.6	3.0	2.3	6.0
9	3.4	2.6	3.1	3.8	1.6	1.0		3.0	3.8	4.9	1.4	3.9
10	3.2	3.5	3.4	3.2	0.4	0.8		4.5	2.2	2.5	1.5	4.1
11	4.6	3.7	3.3	3.9	1.2	0.9		2.7	1.8	3.1	5.1	5.2
12	3.1	4.0	4.4	4.3	0.9	1.2		2.9	2.9	0.9	2.4	4.2
13	3.6	4.7	3.3	4.2	0.6	1.3		2.5	3.6	1.8	2.5	3.7
14	4.0	5.0	4.4	3.6	1.1	2.1		2.5	2.5	1.6	2.3	3.7
15	4.6	4.2	3.0	4.2	0.9	1.6	4.4	0.6	1.3	2.2	1.8	4.0
16	4.1	3.0	5.6	1.5	1.3	2.0	3.8		3.1	2.2	2.2	6.0
17	4.2	2.9	6.4	3.3	1.1	1.1	8.4		3.6	2.5	2.1	4.3
18	2.9	3.1	3.2	2.9	1.3	1.9	1.7		2.9	0.8	2.0	3.8
19	3.1	3.1	2.9	4.1	1.0	1.0	1.8	2.7	2.3	3.1	2.9	5.3
20	3.0	3.9	3.7	4.7	0.6	1.8	2.3	2.6	2.5	1.3	2.6	5.6
21	4.1	3.4	4.1	3.7	0.8	2.0	2.9	3.0	2.0	1.6	2.9	3.6
22	2.9	2.8	4.5	5.1	1.1	1.5	2.9	3.5		2.3	2.7	4.4
23	2.7	3.1	4.1	1.4	1.3	1.6	2.2	5.9	1.7	2.0	2.4	6.7
24	3.6	4.5	4.1	2.6	2.8	1.5	1.2	3.0	1.8	2.1	2.4	3.8
25	2.6	4.2	5.1	2.0	1.1	1.8	2.3	2.5	3.1	2.9	2.6	2.3
26	4.0	3.4	3.2	4.6	1.4	1.2	2.1	2.7	2.6	2.0	2.3	3.3
27	3.9	1.7	4.0	3.7	1.6	2.5	2.2	2.2	2.3	4.5	2.4	2.9
28	4.7	2.6	3.3	6.0	1.5	2.3	2.4	1.1	2.4	1.1	2.2	3.0
29	3.1	3.4	3.1	5.0		1.2	1.6	2.2	2.4	1.9	3.8	4.1
30	3.1	2.4	3.7	3.7		1.4	2.9	1.5	2.5	1.6	5.9	3.2
31	3.7		2.9	3.5		1.2		2.1		1.1	3.9	
Mean	3.72	3.26	3.64	3.79	1.27	1.45	2 81	2.68	2.66	2.23	2.71	4.30
Std Dev	0.65	0.77	0.92	1.10	0.55	0.45	1.70	1.10	0.93	0.96	1.05	1.07
Maximum Monthly	4.9	5.0	6.4	6.0	2.8	2.5	8.4	5.9	6.1	4.9	5.9	6.7
Seasonal				6.4					8.4			
Annual							8.4					

TABLE 9. DAILY MAXIMUM DOWNDRAFT (ms^{-1}) RECORDED AT 150-METER LEVEL

	Winter						Summer					
Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep
1	3.8	2.5	2.6		2.5	1.7		5.7	4.8	4.6	5.6	3.4
2	5.5	2.3	3.0		2.0	1.5		5.4	5.3	4.5	4.8	3.7
3	4.0	3.3	1.5	1.7	5.7	4.0		6.1	3.2	5.8	4.0	3.2
4	2.9	2.5	1.8	2.1	1.6	1.6		5.8	5.0	5.9	4.7	3.8
5	3.1	2.2	2.1	2.5	1.8	1.7		3.9	4.9	5.3	5.6	2.9
6	3.0	3.4	1.7	2.5	2.4	1.4		4.4	5.8	5.6	4.7	3.2
7	2.5	3.4	2.9	1.7	3.0	1.2		5.4	6.4	5.4	4.3	3.9
8	1.9	2.7	1.9	2.7	1.7	1.8		4.7	4.8	4.0	4.3	3.0
9	2.9	2.5	2.6	2.6	1.6	2.1		5.4	3.0	5.7	4.9	4.9
10	3.4	2.6	2.0	2.3	1.0	3.0		3.9	4.8	4.7	6.0	3.0
11	3.6	3.6	3.2	2.1	1.4	1.4		4.7	4.6	7.8	4.6	3.0
12	3.8	2.6	1.5	3.7	1.4	1.2		7.0	4.5	4.1	5.1	4.5
13	2.7	2.9	1.7	2.9	1.1	3.0		4.7	5.2	5.0	3.8	4.3
14	2.3	3.0	1.9	3.2	1.3	1.7		5.3	4.5	5.8	4.9	3.7
15	2.7	2.9	2.3	3.8	1.3	2.1	4.7	3.1	4.8	5.5	5.6	3.5
16	2.8	2.7	4.0	1.7	2.0	2.6	5.4		5.6	6.2	5.1	6.0
17	2.5	2.1	4.5	2.2	1.1	1.4	5.8		4.0	4.9	5.0	2.6
18	3.8	2.8	2.7	1.9	1.0	1.4	6.5		4.7	4.6	4.9	4.2
19	3.3	3.2	2.3	2.6	1.6	1.4	5.4	5.3	5.3	6.3	4.5	4.0
20	4.6	3.1	1.8	2.8	1.0	2.0	6.3	4.7	5.7	4.5	4.8	2.7
21	3.3	4.1	3.4	1.7	1.1	2.2	3.7	5.6	6.2	3.3	6.0	2.4
22	2.9	3.0	2.8	2.6	1.0	1.5	6.3	6.1		3.8	6.3	1.8
23	3.9	3.0	2.3	1.5	1.5	1.0	6.0	5.1	4.8	5.7	5.8	4.1
24	4.1	2.7	2.5	2.3	1.7	2.4	5.2	5.0	5.1	5.5	5.6	3.1
25	3.1	4.0	3.6	1.5	1.2	1.7	5.7	5.3	4.8	4.6	5.4	2.7
26	3.3	2.8	2.6	2.3	2.1	0.6	4.9	4.5	4.5	4.8	4.3	3.2
27	3.2	2.0	3.4	3.0	2.6	1.5	6.1	5.4	4.6	4.4	5.5	3.4
28	2.7	2.8	2.7	2.6	1.6	1.9	4.9	5.2	5.4	4.1	6.0	3.4
29	2.9	2.2	3.2	3.9		2.0	5.6	5.4	4.5	4.5	3.9	3.0
30	3.5	3.7	2.1	2.8		2.1	5.1	6.3	4.7	4.6	4.1	2.6
31	3.5		2.2	2.3		0.9		6.5		5.3	3.8	
Mean	3.27	2.89	2.54	2.47	1.76	1.81	5.48	5.21	4.88	5.06	4.96	3.44
Std Dev	0.71	0.53	0.74	0.65	0.94	0.68	0.73	0.83	0.73	0.89	0.71	0.83
Maximum												
Monthly	5.5	4.1	4.5	3.9	5.7	4.0	6.5	7.0	6.4	7.8	6.3	6.0
Seasonal			5.7						7.8			
Annual						7.8						

TABLE 10. PERCENTAGE FREQUENCY DISTRIBUTIONS OF DAILY MAXIMUM UPDRAFTS IN WIND SPEED INTERVALS OF 0 TO <2, 2 TO <4, AND 4-UP (ms^{-1}) BY MONTHS AND LEVELS

		Winter						Summer					
Level (m)	Wind Speed (ms^{-1})	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep
10	0.0-<2.0	32.26	30.00	77.42	51.06	10.71	0	0	6.45	10.00	12 90	12.90	33.33
	2.0-<4.0	67.74	56.67	19.35	32.26	75.00	77.42	83.33	83 87	83 33	83.87	83.87	66.67
	4.0-Up	0	6.67	3 23	3.23	14.29	22.58	6.67	0	3.33	3.23	3.23	0
	Missing	0	6.67	0	6.45	0	0	10.00	9.68	3.33	0	0	0
18	0.0-<2.0	0	0	0	0	0	0	0	0	0	0	0	0
	2.0-<4.0	19.35	33.33	80.65	54.84	21.43	3.23	6.67	9.68	16.67	3.23	9.68	20.00
	4.0-Up	80.65	60.00	19.35	38.71	78.57	96.77	83.33	80.65	80.00	96.77	90.32	80.00
	Missing	0	6.67	0	6.45	0	0	10.00	9.68	3.33	0	0	0
60	0.0-<2.0	51.61	23.33	38.71	45.16	21.43	3.23	3.33	16.13	16.67	6.45	22.58	46.67
	2.0-<4.0	45.16	66.67	54.84	48.39	75.00	90.32	83.33	67.74	76.67	90.32	70.97	50.00
	4.0-Up	3.23	0	6.45	0	3.57	6.45	3.33	6.45	3.33	3.23	6.45	3.33
	Missing	0	10.00	0	6.45	0	0	10.00	9.68	3.33	0	0	0
150	0.0-<2.0	0	0	0	6.45	89.29	83.87	13.33	16.13	16.67	45.16	12.90	0
	2.0-<4.0	58.06	73.33	67.74	48.39	10.71	16.13	33.33	64.52	76.67	48.39	77.42	46.67
	4.0-Up	41.94	20.00	32.26	38.71	0	0	6.67	9.68	3.33	6.45	9.68	53.33
	Missing	0	6.67	0	6.45	0	0	46.67	9.68	3.33	0	0	0

TABLE 11. PERCENTAGE FREQUENCY DISTRIBUTIONS OF DAILY MAXIMUM DOWNDRAFTS IN WIND SPEED INTERVALS OF 0 TO <2, 2 TO <4, AND 4-UP (ms^{-1}) BY MONTHS AND LEVELS

		Winter						Summer					
Level (m)	Wind Speed (ms^{-1})	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep
10	0.0-<2.0	19.35	13.33	61.29	48.39	7.14	3.23	0	3.23	0	9.68	9.68	16.67
	2.0-<4.0	80.65	73.33	38.71	45.16	82.14	87.10	86.67	83.87	86.67	90.32	90.32	83.33
	4.0-Up	0	6.67	0	0	10.71	9.68	3.33	3.23	10.00	0	0	0
	Missing	0	6.67	0	6.45	0	0	10.00	9.68	3.33	0	0	0
18	0.0-<2.0	16.13	36.67	48.39	32.26	17.86	3.23	6.67	19.35	23.33	25.81	9.68	20.00
	2.0-<4.0	67.74	40.00	45.16	51.61	67.86	83.87	63.33	64.52	63.33	67.74	80.65	76.67
	4.0-Up	16.13	16.67	6.45	9.68	14.29	12.90	20.00	6.45	10.00	6.45	9.68	3.33
	Missing	0	6.67	0	6.45	0	0	10.00	9.68	3.33	0	0	0
60	0.0-<2.0	0	0	0	6.45	0	0	0	3.23	0	0	0	0
	2.0-<4.0	74.19	36.67	83.87	77.42	53.57	19.35	0	12.90	26.67	25.81	38.71	66.67
	4.0-Up	25.81	53.33	16.13	9.68	46.43	80.65	90.00	74 19	70.00	74.19	61 29	33.33
	Missing	0	10.00	0	6.45	0	0	10.00	9.68	3.33	0	0	0
150	0.0-<2.0	3.23	0	25.81	22.58	71.43	64.52	0	0	0	0	0	3.33
	2.0-<4.0	83.87	86.67	67.74	70.97	25.00	32.26	3.33	9.68	6.67	6.45	9.68	73.33
	4.0-Up	12.90	6.67	6.45	0	3.57	3.23	50.00	80.65	90.00	93.55	90.32	23.33
	Missing	0	6.67	0	6.45	0	0	46.67	9.68	3.33	0	0	0

TABLE 12. PERCENTAGE FREQUENCY DISTRIBUTIONS OF TIME OF OCCURRENCE OF DAILY MAXIMUM UPDRAFTS IN TIME PERIODS OF 1900 < 0100, 0100 < 0700, 0700 < 1300, AND 1300 < 1900 EST BY MONTHS AND LEVELS

		Winter						Summer					
Level (m)	Time (EST)	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep
10	1900-0100	3.22	3.84	19.35	20.69	7.14	3.23	7.40	3.70	3.45	3.33	9.67	0
	0100-0700	0	11.53	0	6.90	0	3.23	0	0	0	0	0	6.66
	0700-1300	67.74	46.15	54.84	44.83	53.57	45.16	51.85	48.15	58.62	33.33	25.80	40.00
	1300-1900	29.03	38.46	25.81	27.59	39.28	48.39	40.74	48.15	37.93	63.33	64.51	53.33
18	1900-0100	3.22	3.84	9.68	10.34	7.14	6.45	0	3.70	0	3.33	3.22	0
	0100-0700	0	15.38	6.45	6.90	0	0	0	0	0	0	0	3.33
	0700-1300	54.83	50.00	45.16	41.38	53.57	45.16	37.03	48.15	41.38	40.00	38.70	46.66
	1300-1900	41.93	30.76	38.71	41.38	39.28	48.39	62.96	48.15	58.62	56.67	58.06	50.00
60	1900-0100	3.22	8.00	9.68	10.34	3.57	6.45	3.70	7.41	10.34	0	0	3.33
	0100-0700	0	4.00	0	10.34	7.14	3.23	0	0	0	0	0	10.00
	0700-1300	67.74	56.00	83.87	58.62	46.42	54.84	59.25	59.26	51.72	50.00	64.51	56.66
	1300-1900	29.03	32.00	6.45	20.69	42.85	35.48	37.03	33.33	37.93	50.00	35.48	30.00
150	1900-0100	3.22	7.69	6.45	6.90	0	6.45	0	7.41	6.90	0	0	0
	0100-0700	3.22	0	6.45	6.90	0	0	8.69	0	0	0	0	6.66
	0700-1300	64.52	50.00	61.29	51.72	46.42	54.84	56.52	62.96	65.52	46.67	61.29	56.66
	1300 1900	29.03	42.30	25.81	34.48	53.57	38.71	34.78	29.63	27.59	53.33	38.70	36.66

TABLE 13. PERCENTAGE FREQUENCY DISTRIBUTIONS OF TIME OF OCCURRENCE OF DAILY MAXIMUM DOWNDRAFTS IN TIME PERIODS OF 1900 < 0100, 0100 < 0700, 0700 < 1300, AND 1300 < 1900 EST BY MONTHS AND LEVELS

		Winter						Summer					
Level (m)	Time (EST)	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep
10	1900<0100	9.67	7.69	16.13	6.90	7.14	12.90	7.69	3.70	13.79	3.33	9.67	6.66
	0100<0700	3.22	6.79	0	6.90	0	3.23	0	0	0	0	3.22	3.33
	0700<1300	45.16	42.30	58.06	51.72	35.71	41.94	53.84	40.74	37.93	36.67	45.16	36.66
	1300<1900	41.93	42.30	25.81	34.48	57.14	41.94	38.46	55.56	48.28	60.00	41.93	53.00
18	1900<0100	0	11.53	9.68	17.24	10.71	19.35	7.69	3.70	6.90	3.33	9.67	0
	0100<0700	3.22	7.69	6.45	3.45	0	0	0	0	0	0	0	9.99
	0700<1300	54.83	42.30	51.61	41.38	35.71	45.16	53.84	40.74	48.28	33.33	45.16	33.33
	1300<1900	41.93	38.46	32.26	37.98	53.57	35.48	38.46	55.56	44.83	63.33	45.16	56.66
60	1900<0100	0	4.00	6.45	10.34	0	3.23	0	3.70	6.90	0	0	6.66
	0100<0700	0	4.00	0	3.45	0	0	0	0	0	0	0	3.33
	0700<1300	70.96	56.00	80.65	55.17	46.42	61.29	65.38	62.96	51.72	50.00	61.29	60.00
	1300<1900	29.03	36.00	12.90	31.03	53.57	35.48	34.61	33.33	41.38	50.00	38.70	30.00
150	1900<0100	6.45	11.53	6.45	3.45	0	9.68	3.84	0	6.90	0	0	0
	0100<0700	6.45	0	0	6.90	0	6.45	0	0	0	0	0	13.33
	0700<1300	51.61	57.69	67.74	58.62	50.00	54.84	61.53	55.56	55.17	53.33	61.29	66.67
	1300<1900	35.48	30.76	25.81	31.03	50.00	29.03	34.61	44.44	37.93	46.67	38.70	20.00

TABLE 14. PERCENTAGE FREQUENCY DISTRIBUTIONS OF DAILY MAXIMUM UPDRAFTS >, = , OR < DAILY MAXIMUM DOWNDRAFTS BY MONTHS AND LEVELS

		Winter						Summer					
Level (m)		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep
10	Up>Down	29.03	33.33	35.48	38.71	53 57	58.06	30.00	48.39	30.00	54.84	45.16	30.00
	Up=Down	9.67	6.67	0	3.23	7.14	3.23	6.67	9.68	3.33	6.45	9.67	3.33
	Up<Down	61.29	60.00	64.52	51.61	39.29	38.71	53.33	32.26	63.33	38.71	45.16	66.67
	Missing	0	0	0	6.45	0	0	10.00	9.68	3.33	0	0	0
18	Up>Down	96.77	90.00	100.00	90.32	96.43	100.00	86 67	90.32	96.67	100.00	100.00	100.00
	Up=Down	0	6.67	0	0	0	0	0	0	0	0	0	0
	Up<Down	3.22	3.33	0	3.23	3.57	0	3.33	0	0	0	0	0
	Missing	0	0	0	6.45	0	0	10.00	9.68	3.33	0	0	0
60	Up>Down	3.22	0	9.68	83.87	0	3.23	0	3.23	3.33	3.23	6.45	3.33
	Up=Down	0	0	3 23	0	0	0	0	0	0	0	0	3.33
	Up<Down	96.77	100.00	87 10	9.68	100.00	96.77	90.00	87.10	93.33	96.77	93.54	93.33
	Missing	0	0	0	6.45	0	0	10.00	9.68	3.33	0	0	0
150	Up>Down	61.29	70.00	93.55	87.10	17.86	29.03	6.67	6.45	3.33	3.23	9.67	66.67
	Up=Down	3.22	0	0	0	7.14	6.45	0	0	0	0	0	6.67
	Up<Down	35.48	30.00	6.45	6.45	75.00	64.52	73.33	83.87	93.33	96.77	90.33	26.67
	Missing	0	0	0	6.45	0	0	20.00	9.68	3.33	0	0	0

TABLE 15. FREQUENCY OF OCCURRENCE OF 10-MINUTE MAXIMUM VERTICAL GUSTS ≥ 5.0 ms^{-1} BY MONTHS, SEASONS, AND LEVELS

UPDRAFTS

Level (m)	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep
10	0	0	0	0	1	1	0	0	0	0	0	0
18	11	9	8	12	40	80	75	17	8	11	12	18
60	0	1	0	0	0	0	1	1	0	1	0	0
150	0	1	6	6	0	0	1	1	2	0	2	12

DOWNDRAFTS

10	0	0	0	0	1	2	0	0	1	0	0	0
18	1	1	1	0	1	2	4	1	1	0	0	1
60	1	4	1	0	6	12	26	10	10	8	0	1
150	1	0	0	0	1	0	58	41	19	34	24	2

	UPDRAFTS			DOWNDRAFTS		
	Winter	Summer	TOTAL	Winter	Summer	TOTAL
10	2	0	2	3	1	4
18	160	141	301	6	7	13
60	1	3	4	24	55	79
150	13	18	31	2	178	180
TOTAL	176	162	338	35	241	276

TABLE 16. FREQUENCY OF COINCIDENCE OF PRECIPITATION WITH DAILY MAXIMUM VERTICAL GUSTS BY MONTHS, SEASONS, AND LEVELS

UPDRAFTS

	Winter						Summer					
Level (m)	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep
10	0	0	0	4	1	0	0	0	1	1	0	2
18	0	0	0	2	0	0	0	0	1	0	0	1
60	0	1	0	3	0	0	0	0	3	2	0	4
150	0	0	0	2	0	0	0	0	2	2	0	2

DOWNDRAFTS

10	0	0	0	1	1	0	0	0	2	2	1	2
18	0	0	0	4	0	0	0	1	2	0	0	4
60	0	0	0	5	0	0	0	0	2	1	0	3
150	0	0	1	2	0	1	0	1	2	2	0	6

	UPDRAFTS			DOWNDRAFTS		
	Winter	Summer	TOTAL	Winter	Summer	TOTAL
10	5	4	9	2	7	9
18	2	2	4	4	7	11
60	4	9	13	5	6	11
150	2	6	8	4	11	15
TOTAL	13	21	34	15	31	46

TABLE 17. FREQUENCY OF COINCIDENCE OF DAILY MAXIMUM VERTICAL GUSTS WITH MAXIMUM VERTICAL GUSTS ASSOCIATED WITH DAILY MAXIMUM HORIZONTAL GUST

UPDRAFTS

	Winter						Summer					
Level (m)	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep
10	0	1	3	4	1	2	3	6	2	5	3	4
18	0	1	2	5	4	1	0	1	2	5	2	3
60	1	1	4	2	2	1	0	2	3	5	1	2
150	3	1	0	4	3	1	1	2	5	3	3	2

DOWNDRAFTS

10	2	2	0	1	2	4	1	3	7	4	3	6
18	0	1	7	2	3	1	0	3	7	6	1	0
60	2	0	1	3	3	0	2	2	3	6	1	4
150	1	0	1	2	2	1	0	2	2	2	3	3

	UPDRAFTS			DOWNDRAFTS		
	Winter	Summer	TOTAL	Winter	Summer	TOTAL
10	11	23	34	11	24	35
18	13	13	26	14	17	31
60	11	13	24	9	18	27
150	12	16	28	7	12	19
TOTAL	47	65	112	41	71	112

TABLE 18. MAXIMA AND MEANS OF DAILY MAXIMUM UPDRAFTS RECORDED IN 1969 AND 1970's BY MONTHS AND LEVELS

MAXIMUM

Level (m)	Year	Winter Oct	Nov	Dec	Jan	Feb	Mar	Summer Apr	May	June	July	Aug	Sep
10	1969	5.7	5.4	6.0			6.1	3.7	4.7	5.0	5.5	5.2	4.0
	1975	3.9	4.1	4.4	4.2	5.3	5.7	4.6	3.6	4.2	4.6	4.2	3.7
18	1969	5.6	5.3	6.5			5.8	4.1	3.2	3.8	3.7	4.8	3.4
	1975	5.9	5.9	6.1	8.3	9.3	9.4	8.6	6.3	6.1	6.3	6.2	6.0
60	1969	5.2	4.5	4.2			4.4	3.8	4.0	4.9	5.0	5.1	4.5
	1975	4.7	3.0	4.9	3.6	4.6	4.6	4.2	5.1	4.0	5.5	4.4	4.0
150	1969		6.7	4.8			4.7	3.8	4.1	4.4	6.6	4.2	
	1975	4.9	5.0	6.4	6.0	2.8	2.5	8.4	5.9	6.1	4.9	5.9	6.7

MEAN

Level (m)	Year	Winter Oct	Nov	Dec	Jan	Feb	Mar	Summer Apr	May	June	July	Aug	Sep
10	1969	3.13	2.97	3.06			3.14	2.63	3.11	3.02	3.32	2.72	2.57
	1975	2.13	2.36	1.61	1.88	2.93	3.25	2.99	2.70	2.53	2.63	2.56	2.26
18	1969	3.32	3.08	3.57			3.11	2.62	2.18	2.19	2.25	2.62	2.17
	1975	4.54	4.22	3.54	3.76	5.10	5.66	5.60	4.84	4.54	4.69	4.65	4.66
60	1969	3.52	2.91	2.93			2.32	2.60	2.81	2.87	3.04	2.89	2.77
	1975	2.06	2.22	2.38	2.12	2.46	2.83	2.93	2.61	2.58	2.54	2.35	2.15
150	1969		3.26	3.26			2.78	2.39	2.89	2.94	3.31	2.71	
	1975	3.72	3.26	3.64	3.79	1.27	1.45	2.81	2.68	2.66	2.23	2.71	4.30

TABLE 19. MAXIMA AND MEANS OF DAILY MAXIMUM DOWNDRAFTS RECORDED IN 1969 AND 1970's BY MONTHS AND LEVELS

Level (m)	Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep
		Winter							Summer				
MAXIMUM													
10	1969	6.3	5.5	7.5			6.3	3.7	4.8	4.6	5.8	5.7	3.1
	1975	3.8	4.8	2.8	3.1	5.1	5.3	4.6	4.0	5.0	3.4	3.7	4.6
18	1969	6.2	5.8	7.3			5.1	4.6	3.5	3.9	4.0	4.6	3.6
	1975	5.1	5.5	5.1	4.3	5.3	6.3	9.3	5.2	5.3	4.8	4.6	5.3
60	1969	6.2	6.5	8.0			5.1	5.7	6.4	6.6	8.2	5.3	5.5
	1975	5.3	5.6	5.1	4.9	8.6	7.7	8.4	6.2	7.7	5.7	4.8	5.3
150	1969		5.8	7.2			5.8	4.7	5.2	5.9	5.7	6.3	
	1975	5.5	4.1	4.5	3.9	5.7	4.0	6.5	7.0	6.4	7.8	6.3	6.0
MEAN													
10	1969	3.27	3.33	3.49			3.30	2.86	2.92	2.99	3.29	3.16	2.31
	1975	2.40	2.57	1.78	1.95	2.83	3.21	3.03	2.63	2.90	2.49	2.59	2.41
18	1969	3.86	3.74	4.01			3.48	3.13	2.77	2.96	2.50	3.15	2.54
	1975	2.72	2.53	2.24	2.40	2.74	3.11	3.51	2.53	2.53	2.45	2.59	2.57
60	1969	3.95	3.91	4.23			2.96	3.74	4.16	4.52	4.11	3.71	3.89
	1975	3.70	3.99	3.17	3.00	4.36	4.65	5.13	4.43	4.51	4.39	3.98	3.67
150	1969		3.69	4.32			3.85	3.73	3.94	4.50	4.47	4.59	
	1975	3.27	2.89	2.54	2.47	1.76	1.81	5.48	5.21	4.88	5.06	4.96	3.44

TABLE 20. MAXIMUM VERTICAL GUSTS RECORDED DURING HURRICANE AGNES, 1969, AND 1970's BY LEVELS

Level (m)	Agnes 19 June 72	1969	1970's
	UPDRAFTS (ms^{-1})		
10	4.5	6.1	5.7
18	8.8	6.5	9.4
60	7.5	5.2	5.5
150	11.8	6.7	8.4
	DOWNDRAFTS (ms^{-1})		
10	4.3	7.5	5.3
18	7.8	7.3	9.3
60	5.9	8.2	8.6
150	>11.9*	7.2	7.8

* Off Scale

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APPROVAL

AN ANALYSIS OF MAXIMUM VERTICAL GUSTS RECORDED AT NASA'S 150-METER GROUND WINDS TOWER FACILITY AT KENNEDY SPACE CENTER, FLORIDA

By Margaret B. Alexander

The information in this report has been reviewed for security classification. Review of any information concerning Department of Defense or Atomic Energy Commission programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

This document has also been reviewed and approved for technical accuracy.

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